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Near Term Threats of Chemical Weapons Terrorism

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by [Margaret E. Kosal](#)

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Introduction

The use of box cutters and small blades by terrorists during the September 11th attacks has been reported widely, whereas, the use of a chemical agent—"mace, pepper spray, or some other irritant"—in the airplane hijackings is much less well known.^[1] Rather than setting up the proposition that such agents are the "latest-greatest" threat, this work aims to consider the potential threat of improvised chemical agents for terrorist use.

Traditional state-based chemical weapons (CW) programs share three technical characteristics that differ from terrorist use of chemical agents. States invest in substantial infrastructure for CW production and storage. This may be dedicated facilities, as was the case of the former U.S. and Soviet offensive programs, or dual-use facilities as seen in the covert Iraqi and Libyan state programs. States will also invest significantly in physical protection of their own troops and medical intervention in the event of exposure. Finally, traditional CW programs invest in research and development of munitions for open-air battlefield dispersal.

In comparison, non-state actors have shown a propensity to improvise the dissemination method and the agents. The use of improvised distribution methods was observed, most notably, in the 1990s by Japan's quasi-religious doomsday cult, the Aum Shinrikyo, who employed syringes, garbage bags, and condoms to deliver classical chemical warfare agents. But, in more recent incidents, plots, and seizures, both the distribution methods and the agents themselves have been improvised.

Improvised chemical terrorism is critically different from an improvised nuclear or mass effect bioterrorism attack that would likely result in more than one thousand fatalities or 10,000 casualties. To execute an improvised chemical terrorism attack, a group or individual does not need sophisticated knowledge, elaborate engineering or growth requirements, nor complicated dissemination methods.

Improvised explosive devices (IEDs) are currently a tremendous problem for U.S. troops in Iraq, Afghanistan and around the globe. Over half of the U.S. fatalities in Iraq have been due to IEDs, typically roadside bombs. This strongly suggests that there is a significant tacit knowledge base for constructing these types of weapons—one guy in a Mosul garage has not been making them

all. Incorporating chemicals into roadside bombs would not substantially change the military casualties; the scenario would be significantly different, however, for devices used in enclosed spaces like dining tents or civilian facilities.

The path from the street chemistry of high explosives and detonators for IEDs to improvised chemical devices (ICDs) that incorporate commercial chemicals is very short. Conversely, the path from IEDs to effectively weaponized, transgenic biological agents effectively weaponized is a substantial leap for states and, even more so, for terrorists. While U.S. policy is focused on defending against a mass-effect bioterrorism attack, we may be missing a lower-tech threat of much higher probability. Rather than leaping from making bombs to producing mass quantities of aerosolized, genetically engineered, hyper-virulent *Yersinia pestis* (the bacteria responsible for the plague and used as part of the national terrorism preparedness exercise scenarios, TOP OFF 2 and 3), this article examines trends toward improvising both the delivery method (munitions) and the agent for chemical terrorism.

Is there substantive evidence of a shift, an “upping” of the sophistication level, to incorporate chemical agents into such devices? What policy responses can reduce the threat of improvised chemical devices? Is this shift part of a larger escalation to the use of unconventional weapons—that is, weapons of mass destruction (WMD)—by non-state actors? If such a large-scale escalation from IEDs to ICDs were to occur, the number of agents of concern would expand from approximately 50 traditional chemical warfare agents to thousands of known industrial and research chemicals. This analysis should be the basis for policy development regarding threat anticipation, threat reduction, and countermeasures to limit harm to U.S. troops deployed around the world and U.S. civilians at home.

Prior Work

A number of prominent authors have addressed the questions of terrorist desire and capability to pursue chemical or biological weapons.[2] Extensive analysis of terrorist incidents involving chemical and biological agents has been done on well-known incidents, such as the Aum Shinrikyo sarin “gas” attack on the Tokyo subway in March 1995 and the Rajneeshees salad bar dispersal of *Salmonellatyphimurium* bacteria.[3] A far smaller number of researchers have gone the other direction and challenged the precept that biological agents are within the technical capability of most terrorists.[4] At least one renowned terrorism expert has asked why terrorists have not escalated to fulfill the “lurid hypotheses of worst-case scenarios, almost exclusively involving chemical, biological, radiological or nuclear (CBRN) weapons” and “America’s intense preoccupation with the threat of bioterrorism.”[5] None of the authors have considered an escalation to chemical weapons as an outgrowth of “street chemistry,” the chemistry involved in manufacturing IEDs.

Traditional Chemical Warfare Agents with Improvised Dispersal Methods

One type of chemical terrorism—using traditional chemical warfare agents associated with state-based programs, but employing improvised distribution means —has received a great deal of attention.[6] This type of chemical terrorism may have been most infamously utilized by the Aum Shinrikyo cult in the mid-1990’s. Transfer of chemical weapons by those states suspected of operating clandestine offensive chemical weapons programs, such as North Korea—to non-state actors is another example.

Aum Shinrikyo

Aum Shinrikyo was a highly organized and well-financed group, having members with significant technical expertise. While the group succeeded in synthesizing sophisticated traditional nerve agents, they employed rudimentary delivery methods.

In the infamous March 1995 attack on the Tokyo subway system, sarin nerve agent was dispersed via garbage bags punctured by sharpened umbrellas. The nerve agent was manufactured from precursor chemicals the day before and diluted with acetonitrile. Approximately 600 mgs (1.3 lbs) were transferred to 11 polyethylene bags and distributed among five Aum Shinrikyo members. While there were only 12 fatalities associated with the subway attack, more than 5,000 individuals sought medical attention. More than 500 were seriously affected, including a few individuals whose corneas were so damaged that they had to be removed, resulting in permanent blindness. One small, but remarkable, lingering effect of the terrorist incident on the Tokyo population is the lack of garbage cans in public areas; even 10 years later, they are still associated with the sarin attack. This incident vividly illustrates the large-scale panic and disruption that chemical terrorism can produce in major urban areas.

The subway incident was the Aum cult's only foray into chemical terrorism. In the five years leading up to the most renowned sarin attack, Aum Shinrikyo executed at least ten separate attacks. Four months earlier, in December 1994, Aum Shinrikyo released 20 kgs of sarin—from a truck using an industrial sprayer connected to a commercial heater—in the Matsumoto prefecture. The late night attack killed seven people and injured an additional 144 civilians. At least two deaths are associated with Aum Shinrikyo's production of limited quantities of VX nerve agent. Synthesized for dispersal via hypodermic syringes, the attacks specifically targeted enemies of the cult. VX was dribbled on the back of one former cult member's neck in a fatal December 1994 assault in Osaka.^[7] Aum also employed an improvised apparatus at train and subway stations in May and July 1995 to generate the classic choking agent, hydrogen cyanide, from commercial sodium cyanide.

Homegrown Terrorists

Radical Islamists are not today's only potential terrorists of concern, particularly with respect to chemical terrorism. Domestically, use of improvised chemical devices was part of the case against William J. Krar of Tyler, Texas.^[8] An outspoken anti-government white supremacist, Krar was a traveling arms salesman. In January 2003, he was arrested in Tennessee during a routine traffic stop for handgun and drug possession. Along with conventional weapons, such as knives, stun guns, smoke grenades, over 250 rounds of ammunition, fuses, and hand combat items, Krar's rental car contained a "syringe of an unknown substance, one white bottle with an unknown white substance, forty wine like bottles of unknown liquid ... (and) three military style packaged atropine injections."^[9] A year later, after a package from Krar containing fake Department of Defense (DOD), Defense Intelligence Agency (DIA) and United Nations (UN) badges was delivered to the wrong address, federal investigators uncovered a disturbing array of weapons in an east Texas storage space rented by Krar and his female companion, Judith Bruey . Krar had amassed a sizable weapons cache, including half a million rounds of ammunition, hundreds of explosives, illegal firearms and stockpiles of cyanide salts and strong acids.

In his weapons armory were a number of improvised devices in varying stages of construction. The most complete device combined solid sodium cyanide with a strong acid to generate 440 grams of hydrogen cyanide (HCN). This would be, hypothetically, enough to kill almost 6,500 people based on percutaneous exposure. It could also kill half the people in a 9 x 40 x 40 foot enclosure in one minute.

What did Krar's hydrogen cyanide device look like? He had placed just under two pounds of sodium cyanide powder—that Krar indicated he obtained from an electro-plating company^[10]—in an old ammo box . It was to be combined with less than a half -liter of hydrochloric acid (HCl), or just over 0.7 liters of nitric acid (HNO₃), to produce the hydrogen cyanide vapor . One four-liter bottle of acid of a standard research size used at university and research facilities—would provide excess acid. Alternatively, excess acid could readily be obtained from eight bottles of a popular commercial toilet cleaner.^[11] This was a readily concealable and easily transportable contraption, one that could easily fit in a small suitcase or be carried in a backpack.

Al Qaeda

Al Qaeda's exploits in Afghanistan, testing unspecified lethal vapors on dogs and rabbits, have been well-covered in the commercial media.^[12] Additional evidence of and analysis on al Qaeda's extensive interest in chemical warfare agents was noted in a 2005 Intelligence Commission report.^[13] U.S. troops are reported to have recovered "trace amounts of two common chemicals that can be used to produce a blister agent," most likely sulfur monochloride (S_2Cl_2) or thiodiglycol ($\text{S}(\text{C}_2\text{H}_4\text{OH})_2$). It was also reported that al Qaeda "almost certainly" had obtained or produced a number of traditional choking agents, such as chlorine, hydrogen cyanide, and phosgene. Those chemical warfare agents represent products commercially available or readily synthesized with basic skills, equipment and minimal infrastructure. These are not complex reactions requiring sophisticated laboratory equipment, controlled power sources for sensitive heating or cooling, or controlled environmental conditions.

In September 2003, the Department of Homeland Security issued an "Information Bulletin" alerting law enforcement and allied professionals regarding suspicions that al Qaeda intended to utilize an improvised method to generate hydrogen cyanide or cyanogen chloride from cyanide salts.^[14] A primitive binary weapon for generating a choking agent, the device uses dual-purpose commercial chemicals, requires little or no training for assembly and operation, but does require some basic chemistry knowledge for initial design.

Improvised Chemical Agents

There is another type of potential chemical terrorism that has received almost no attention. Legitimate industrial or research chemicals, not traditionally associated with state-based chemical weapons programs, may be co-opted in order to generate improvised choking, blister, or nerve agents. In this case, both the agents themselves and the dispersal method are improvised.

Using reports available in the open-source literature, there appears to be an increasing interest among radical Islamists in exploiting fairly sophisticated chemistry for terrorist purposes. One case will be examined in detail.

Osmium Tetroxide

March 2004 Osmium Tetroxide Plot. A March 2004 plot disrupted in Britain was intended to combine an industrial chemical with an improvised explosive device to generate a choking and blistering agent. Osmium tetroxide (OsO_4) serves legitimate functions in biological research and in specialized chemical industry, but its suitability as a terrorist agent—a dual-use compound—is limited, despite the characterizations of it generating "chemical fallout."^[15]

GCHQ, the British electronic eavesdropping intelligence agency, learned that a group of terrorists were discussing the use of OsO_4 during phone calls among themselves, both within Britain and to Pakistan.^[16] Hundreds of British anti-terrorism police tracked the group over the course of several months.^[17] On March 30, 2004, raids were conducted at 24 locations throughout the London area. Authorities arrested eight British citizens—some of Pakistani origin, a Canadian, and a British-Algerian—who were allegedly involved in the planning stages of a terrorist attack. In the following week, reports emerged that these suspects, allegedly sympathetic to al Qaeda, were researching the potential of detonating a chemical bomb in a crowded, civilian location within London^[18]—targeting Gatwick airport, the London subway, or other enclosed high-traffic areas. Fortunately, the suspects reportedly were not able to acquire the osmium tetroxide before being intercepted by authorities.

Although al Qaeda has previously produced training manuals containing plans for use of choking agents, this is the first time osmium tetroxide has been included among the list of possible chemical agents. This is the first incident in the open literature in which the chemical has been connected with terrorism. Although this plot did not progress beyond the planning stages, the potential use of osmium tetroxide has raised new fears about al Qaeda's pursuit of dual-use chemicals as terrorist weapons. It has also encouraged discussion about the potential lethality of such a substance when combined with a conventional explosive.

Scientists were already familiar with the use and effects of OsO₄ even though those reports introduced the general public to the compound for the first time. OsO₄, occasionally called osmic acid, is a colorless to pale yellow solid at room temperature. An open canister of OsO₄ left in an enclosed area would be readily noticeable based on the characteristic pungent, ozone- or chlorine-like smell. The solid has a high vapor pressure, meaning it readily evaporates at room temperature. The vapor pressure of a chemical is important in determining the inhalation hazard. Liquids with very low vapor pressures, like VX nerve agent, do not evaporate readily and, therefore, are considered a much more significant threat for exposure via direct skin contact. Solids and liquids with no vapor pressure do not evaporate and therefore do not pose an inhalation hazard unless they are mechanically aerosolized.

Physiological Effects of OsO₄ Exposure. Osmium tetroxide is highly toxic and a rapid oxidizer. Severe reactions may result through all routes of exposure: inhalation, ingestion, contact with the eyes and other mucous membranes, and contact with skin. Because of its volatility, the vapor hazard is usually emphasized. Very short-term contact with the vapor may generate a lachrymation (tear-causing) response, accompanied by coughing, headaches, and dizziness.[19] Lengthier exposure can cause severe chemical burns to the eyes, skin, and respiratory tract. Symptoms may not be noticed until several hours following exposure. This delayed-effect feature may make this compound attractive to terrorists as a chemical weapon. People may not realize the extent of the toxic effects of a compound to which they have been exposed immediately; rather the damage will be occurring as they continue their day. Another delayed effect as a result of substantial inhalation exposure is an accumulation of fluid in the lungs (edema)—eventually leading to “dryland-drowning.” Exposure to osmium tetroxide dissolved in water will turn the skin black. Painful burns or dermatitis may result depending on the concentration. It is not known, however, to be cancer-causing. Among the most insidious effects of osmium tetroxide is its capacity to cause irreversible blindness—literally turning the corneas black.[20]

OsO₄ can be compared to traditional chemical warfare agents (see [Table 1](#)). The first appearance of a physiological response, also known as a threshold effect, is observed at a lower concentration for osmium tetroxide vapor exposure than for phosgene (CG), sulfur mustard (HD), or sarin nerve agent (GB). At first glance, the inhalation hazard associated with OsO₄ is comparable to that of the traditional asphyxiant phosgene and blister agent sulfur mustard based on lethal inhalation concentrations. Phosgene is a gas at ambient conditions, so all of the material will be available as an inhalation hazard. On the other hand, sulfur mustard is a liquid with a fairly low vapor pressure,[21] making it less volatile than OsO₄. This means that, in an enclosed area, there will be over 150 times more vapor available with OsO₄ than with sulfur mustard vapor.

While the lethal inhalation concentration of OsO₄ is substantially larger than that for sarin, again the decreased volatility of the traditional warfare agent should be considered in evaluating the relative threat. Under similar conditions, there will be six times more OsO₄ vapor in an enclosed area compared to sarin vapor. The overall inhalation risk for osmium tetroxide is estimated to be closer to sarin nerve agent than sulfur mustard or phosgene gas.

Legitimate Uses of OsO₄. This substance is used primarily in the preparation of biological samples—a technique called fixation or fixing—to help maintain cellular and sub-cellular structures that would otherwise be damaged during further processing. Fixing is an important step in most biological applications of electron microscopy—looking at very small structures with

electrons rather than light. OsO₄ reacts with the olefins in fatty acids and other tissues. Fixing has some similarities to staining used in traditional microbiology. The osmium atomic nucleus helps make the biological structures more easily seen under an electron microscope.

Osmium tetroxide is also used in specialized organic chemistry reactions[22]—such as the synthesis of the synthetic human hormone norestradiol[23]—and industrially significant glycol compounds. These reactions using solid osmium tetroxide are most commonly done on a laboratory scale.

Table 1: Toxicity Comparison of Osmium Tetroxide with Traditional Chemical Warfare Agents

	Threshold effects (mg / m ³)	LCt 50* (mg-min / m ³)	LD 50** (mg / kg)
Osmium Tetroxide (OsO ₄)[24]	0.1 - 0.6	1316	162
Phosgene (PG)[25]	2	3200	n/a***
Sulfur Mustard (HD)[26]	12-500	1500	100
Sarin (GB)[27]	2	70	24.3

*LCt 50 is the vapor concentration that will cause death by inhalation in fifty percent of a population.

** LD 50 is the liquid concentration that will cause death via exposure through the skin (percutaneous), in this comparison, in fifty percent of a population. Values are given in mg per kg of total body weight; a 150 lb human weighs approximately 68 kg.

*** n/a = not applicable. Phosgene is a gas at ambient conditions.

Commercial Availability . Osmium tetroxide is commercially available as either a solid or as an aqueous solution (less than 6% OsO₄ by weight, due to limited solubility in water). Commercial quantities are typically very small and prices are high. Cost for the largest, commercially available units from a leading U.S. chemical supplier range from \$118 for 1 gram of the solid compound to \$195 for a 25 mL ampoule containing 2.5% OsO₄ by weight, dissolved in water (0.625 grams OsO₄ per vial). A terrorist attempting to use OsO₄ in the creation of a chemical terrorist weapon would most likely be hindered by its high cost. There would also be a danger to the terrorist in attempting to prepare an improvised explosive device containing large quantities of the chemical compound.

In packages of five grams or more, larger quantities are commercially available in which osmium tetroxide is bound to a polymer backbone. The polymer backbone, or support, eliminates the vapor hazards associated with solid OsO₄. Since immobilized OsO₄ was designed specifically to protect industrial workers, its utility as a weapon, even in large quantities, would be extremely low.

A leading U.S. chemical supplier of OsO₄ does not take any special precautions regarding sale of the chemical. But because of the potential dual-use nature of many chemicals with legitimate industrial and research purposes, all orders are screened prior to shipment.

Decontamination. If an OsO₄-containing solution were to be used as a chemical terrorist weapon, it could be decontaminated with copious amounts of any unsaturated cooking oil or dry milk.[28] Once a solution is black, the risk of rampant oxidation (burning) is abated.

Viability as a Chemical Terrorism Weapon. The feasibility of using a bomb to disperse OsO 4 is highly suspect. When heated, OsO 4 rapidly decomposes to OsO 2, which is effectively a rock. OsO 2 is used as a ceramic resistor in specialty electronic applications. Rather than generating chemical fallout, as in a dirty bomb scenario, the inhalation hazard would be destroyed with the bomb explosion. In addition to the difficulties and hazards faced by anyone seeking to use OsO 4 as a dirty bomb, the effect of the compound would be minimal in an open space and it would not leave lasting contamination in the same manner as a radioactive bomb. Because it is such a rapid oxidizer, it would most likely first enhance the combustion of the materials used for the bomb. As an oxidizer for an improvised explosive device, OsO 4 is a very expensive choice and very risky for the bomb assembler. Thus, its utility in the creation of a dirty bomb, when combined with conventional explosives, is questionable.

Chemical terrorism incidents are not limited to those events involving explosives or incendiary materials. The danger and harm from OsO 4 as a chemical agent alone is substantially greater than as part of a dirty bomb. As a solid, the major danger comes from its inhalation. Therefore, OsO 4 presents the greatest hazard in an enclosed space with poor ventilation, whereas it would not be effective in a large, open air venue. In solution form, the major danger is via the skin (percutaneous) or ingestion.

As a terrorist weapon, however, the biggest problem with osmium tetroxide is its nature as a rapid, indiscriminate oxidizer. OsO 4 doesn't distinguish between membranes in the human eye and lungs, plants, rubber, or cooking oil. While it has the potential to inflict horrifying damage to the body in the form of chemical burns and blindness, it does not specifically target a critical physiological function as nerve agents do. A second limitation as a terrorist weapon is its volatility. The persistency of both sarin and VX substantially exceeds that of OsO 4.

OsO 4, although unquestionably a lethal compound, is not estimated to be a viable dirty bomb hazard as it will readily decompose if utilized with explosives. In comparison to traditional chemical warfare agents, OsO 4 has similarities to the choking agents: high volatility and targeting of the respiratory system. It resembles the blister agents, like sulfur mustard, in that it attacks the eyes, burns the skin (by a different molecular mechanism than sulfur mustard), and has some delayed effects. Unlike sulfur mustard, however, the blindness from OsO 4 vapor exposure is permanent. Because of its high volatility in combination with its high toxicity, the inhalation risk of OsO 4 vapor verges that of sarin nerve agent; but it does not target critical nerve connections that control the cardiovascular and respiratory systems as the nerve agents do. Additionally, the persistency of osmium tetroxide vapor is low in comparison with the nerve agents and sulfur mustard.

The incorporation of osmium tetroxide, a fairly obscure inorganic compound, into terrorist training manuals, suggests some familiarization with advanced undergraduate level chemistry. The British terrorist suspects recognized the deleterious health effects, but their plan to incorporate OsO 4 into a conventional explosives bomb showed a lack of sophisticated and detailed understanding of inorganic chemistry. Their level of knowledge might be indicative of a member who is a graduate-level individual or a technician. Either one could be in a research lab or industrial biochemistry, molecular biology, or biomedical engineering laboratory and have access to OsO 4. The plot does not point to people with graduate-level experience in synthetic chemistry or significant experience in an industrial setting. This incident may also hint at an escalating terrorist interest in pursuing non-traditional chemicals as improvised weapons. Put concisely, in a chemical weapon incident, one cannot assume just chemists are involved; similarly in a biological weapon incident, one cannot assume just biologists are involved. One is more likely to obtain skills for dissemination of biological agents from experience and expertise in polymer science, materials engineering, or chemical engineering rather than from modern molecular biology.

Hydrazoic Acid

Another example of an improvised chemical weapon is the reported interest in hydrazoic acid (HN 3)—a toxic gas generated when from solid sodium azide (NaN 3) is combined with an aqueous oxidizer. Large amounts of the chemical compound were recovered from two Islamist terrorist groups with ties to al Qaeda—the Jemaah Islamiyah in Malaysia and Indonesia[29] and part of the April 2004 plot discovered in Jordan linked to Mus'ab al-Zarqawi.[30] Malaysian police confiscated an unspecified amount of sodium azide as part of a cache of explosive chemicals outside of Kuala Lumpur that they linked to Jemaah Islamiyah, the terrorists responsible for the October 2002 Bali bombing. There is some dispute as to whether the cache of material seized in April was intended for a chemical bomb or a conventional explosion.

Sodium azide (NaN 3) is a thermodynamically unstable, but kinetically inert, chemical that generates nitrogen gas (N 2) when heated. It is used commercially in automotive airbags and has legitimate use as a fungicide and pesticide. The compound has also long been used to generate shock-sensitive detonators. The addition of an acid yields hydrazoic acid, a poisonous gas more lethal than the traditional blood agent, hydrogen cyanide. It is also a lethal chemical when ingested and has previously been used in criminal homicides and suicide, particularly in Japan.[31]

Iraqi Insurgents

Reportedly the Al-Abud network in Iraq has shown interest in chemical weapons.[32] The Jaysh Muhammed (JM) formed the Al-Abud network in late 2003 in response to Operation Iraqi Freedom. Initial attempts to produce traditional agents were unsuccessful, so the terrorists shifted to improvised agents. They recruited an “inexperienced Baghdad chemist” to attempt to produce two traditional chemical warfare agents—the nerve agent tabun and the vesicant nitrogen mustard. Precursors were obtained from “chemical suk district” and “farmers” who looted state companies. After initial, unsuccessful attempts, the terrorist network shifted emphasis to the production of “napalm” and sodium fluoride acetate with which to fill conventional mortars obtained from JM contacts. The specific composition of the “napalm” is not provided.

Related Potential Terrorist Threats

There are two additional types of improvised chemical terrorism that have not been addressed directly in this study. The first is deliberate attack on an industrial chemical facility as a means to cause either mass effect terrorism—release of toxic vapor—or the destruction of a nation's critical infrastructure.[33] The Union Carbide disaster in Bhopal, India in December 1984 is illustrative of the catastrophic scale that is possible from mass-effect terrorism. There were more than 3,800 fatalities from the initial release of methyl isocyanate in that accident, and it is estimated that 200,000+ were affected during the ensuing 20 years. Attacks may also involve targeting commercial infrastructure as a means of economic terrorism or to disrupt the critical infrastructure of the nation.[34]

According to the U.S. Army Surgeon General's Office, the worst-case scenario for a terrorist attack on a domestic, industrial chemical facility is “up to 2.4 million people killed or injured—close to the number estimated by chemical companies themselves,” as calculated by the U.S. Army Surgeon General's Office.[35] More than 15,000 facilities throughout the U.S. produce, store, and transport industrial chemicals in substantial quantities.[36] In 1996, the U.S. Environmental Protection Agency (EPA) determined “a worst-case release” could endanger more than one million people located near any one of its 123 identified facilities.[37] More recent assessments assert that, “at present, about 600 facilities could potentially threaten between 100,000 and a million people ... [Another] 2,000 facilities could potentially threaten between 10,000 and 100,000 people.”[38] The numbers are staggering.

A speaker at an industry-sponsored Chemical Security Summit surmised, “You’ve heard about sarin and other chemical weapons in the news. But it’s far easier to attack a rail car full of toxic industrial chemicals than it is to compromise the security of a military base and obtain these materials.”^[39] Attacks on industrial chemical facilities may be seen as one element of the greater shift in chemical warfare from the state-based chemical weapons programs toward improvised agents, munitions, and methods for terrorism.

The second additional type of improvised chemical terrorism involves unsecured or under-secured traditional chemical warfare agents and munitions. The principal hazards of this sort are the stockpiles of former Soviet Union,^[40] although there are several others. Alleged chemical proliferator states, such as Pakistan and North Korea, are suspected of a willingness to sell to terrorists. Insurgents have reportedly threatened use of looted Iraqi chemical munitions against U.S. troops.^[41] Recovery of abandoned or sea-dumped chemical munitions may pose an extreme threat. And, even while highly secure, the destruction of the remaining U.S. chemical weapons stockpiles is being accelerated since these sites are considered potential terrorist targets following the September 2001 terrorist attacks.

Conclusions and Recommendations

The path from street chemistry IEDs to improvised chemical devices is very short. There are two divergent concerns: 1) traditional CW agents dispersed via improvised methods, and 2) improvised agents and delivery methods. Although Japan’s Aum Shinrikyo mimicked a small-scale version of state-based programs, it is not the only model—and may not be the best model—for urban chemical terrorism. Lone individuals or small groups may improvise more. Large quantities and extensive facilities are not required for urban chemical terrorism. Within the global Salafist jihad, there is evidence to suggest an increasing interest in exploiting fairly sophisticated chemistry for terrorist purposes.

Chemical terrorism is likely to be a crime of opportunity for those familiar with chemistry and having access to chemicals. Controlling the materials for use as improvised chemical agents is not a trivial issue, requiring the list of agents of concern to be expanded from the approximately 50 associated with traditional CW to thousands of known commercial chemicals. Former Secretary of the Navy, Richard Danzig, has written on what he calls the “reload” phenomenon: “Our national power to manage the consequences of repeated biological attacks could be exhausted while the terrorist ability to reload remains intact.”^[42] With ICDs, the “reload” factor—the potential to repeat an attack, multiple times—is equivalent to or higher than that for biological terrorism given the ubiquitous dispersion of chemical compounds throughout the industrialized world.

Perhaps basic knowledge and materials are too globally widespread to justify efforts to control the capability of terrorists to co-opt them for malfeasant uses. Unlike the stocks of fissile material from the Cold War that can be secured, materials for bioterrorism—with some exceptions—are widespread and unsecured

Leaping from this threat assessment directly to recommendations for governmental or individual action is not something I want to advocate. Rather this threat assessment needs to be considered as part of a broader, comprehensive assessment of terrorist weapons and terrorist targets, which should contribute to policy decisions about funding for research, countermeasures and emergency response. It is a piece of a much wider puzzle, not a ‘turf war.’ While the probability of attack employing ICDs is high, the potential consequence of an improvised nuclear or mass-effect bioterrorism event is much higher. This type of threat assessment needs to be integrated with robust technical evaluations of the risks of bioterrorism, nuclear terrorism and radiological terrorism. Threat assessments also should be integrated into the dialogue of those

involved in emergency response, as well as those involved in the experimental laboratory research that may have implications for homeland defense and international security.

About the Author

Dr. Margaret Kosal is a Science Fellow at Stanford University's Center for International Security and Cooperation (CISAC). Her research has explored a range of issues relating to biological and chemical terrorism and nonproliferation. Specific interests include the entanglement of emerging and dual-use technologies, such as nano- and biotechnology, that impact security concerns. Most recently, she has published research on proliferation and terrorist risks of nanotechnology and on an unaddressed issue of agricultural terrorism. She is currently leading a study of chemical and biological weapons detectors and the integration of policy and technical issues for civilian use, including attribution and verification. She has also investigated the unanticipated role of the public in chemical weapons destruction and their impact on an international arms control treaty.

She received her B.A. in Chemistry from the University of Southern California in Los Angeles and did her doctoral work at the University of Illinois at Urbana-Chicago, investigating the synthesis and behavior of solid-state porphyrinic nanoporous networks, resulting in the publication of seven papers and a book chapter. She continued at the University of Illinois as a post-doctoral researcher exploring thin-film molecular recognition materials that mimic human proteins. She has also held positions at Northwestern University's Feinburg School of Medicine and at the Monterey Institute of International Studies' Center for Nonproliferation Studies (CNS). In early 2001, Kosal and three colleagues founded a sensor company, ChemSensing, leading research on the detection of explosives, chemical agents, neuroactive poisons and bacterial biological warfare agents.

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